

CLAIMS

1. A conduit having its surface or a portion of its surface coated with a fluid-repellent layer wherein said layer comprises, or is produced from, a fluorocarbon silane or a substantially aqueous emulsion; said emulsion comprises or is produced from (1) a fluorocarbon silane or its hydrolyzate, (2) water, and (3) optionally a surfactant, a silicon compound, a catalyst which is an acid or base, or combinations of two or more thereof; said fluorocarbon silane has the formula $R_f-(CH_2)_p-Si\{-(O-CH_2CH_2)_n-OR^1\}_3$; said silicon compound is a silicate or an organoalkoxysilane; R_f is a C_{3-18} perfluoroalkyl group or combinations of two or more thereof; each R^1 is independently one or more C_{1-3} alkyl groups; p is 2 to 4; and n is 2 to 10.
2. A conduit according to claim 1 wherein said conduit is a nozzle.
3. A conduit according to claim 1 wherein said layer has a thickness of from about 0.1 nm to about 10,000 nm.
4. A conduit according to claim 2 wherein said layer has a thickness of from about 1 nm to about 1000 nm.
5. A conduit according to claim 3 wherein said emulsion comprises or is produced from said hydrolyzed fluorocarbon silane, said surfactant, said silicon compound, and said catalyst.
6. A conduit according to claim 4 wherein said emulsion comprises or is produced from said hydrolyzed fluorocarbon silane, said surfactant, said silicon compound, and said catalyst.
7. A conduit according to claim 5 wherein said fluorocarbon silane is perfluoro alkyl ethyl tris(2-(2-methoxyethoxy)ethoxy)silane, perfluoro alkyl ethyl tris(2-(2-methoxyethoxy)ethoxy) silane, or combinations thereof.
8. A conduit according to claim 5 wherein said silicon compound is a silicate or organoalkoxysilane, said silicate has the formula of $Si-(R)_4$, each R is independently OCH_3 , OCH_2CH_3 , $(OCH_2CH_2)_mOCH_3$, $m=1-10$, or combinations of two or more thereof; said organoalkoxysilane has the formula of $R^2_qSi(OR^3)_{4-q}$, each R^2 is independently an alkyl group containing about 1 to about 10 carbon

atoms; each R³ is independently an alkyl group containing 1 to about 3 carbon atoms; and q=1-3.

9. A conduit according to claim 8 wherein said fluorocarbon silane is perfluoro alkyl ethyl tris(2-(2-methoxyethoxy)ethoxy)silane, perfluoro alkyl ethyl tris(2-(2-methoxyethoxy)ethoxy)ethoxy) silane, or combinations thereof.

10. A conduit according to claim 9 wherein said silicon compound is tetrakis(2-(2-methoxyethoxy)ethoxy)silicate, dimethyldimethoxysilane, methyltrimethoxy silane, methyltriethoxysilane, 3-aminopropyltriethoxy silane, N-(2-aminoethyl)3-aminopropyldiethoxy silane, 3-glycidoxypropyltrimethoxy silane, one or more partial condensation products thereof, or combinations of two or more thereof.

11. A conduit according to claim 10 wherein said surfactant is R_f¹-CH₂CH₂-O-(CH₂CH₂O)₁₁-H, C₉H₁₉-C₆H₄-O-(CH₂CH₂O)₅₀-H, R_f¹-CH₂CH₂SCH₂CH(OH)CH₂N(CH₃)₃⁺Cl⁻, C₁₂H₂₅(OCH₂CH₂)₄OSO₃⁻NH₄⁺, C₁₂H₂₇-C₆H₄-SO₃⁻Na⁺, or combinations or two or more thereof wherein R_f¹ is a C₃₋₁₈ perfluoroalkyl group.

12. A conduit according to claim 6 wherein said fluorocarbon silane is perfluoro alkyl ethyl tris(2-(2-methoxyethoxy)ethoxy)silane, perfluoro alkyl ethyl tris(2-(2-methoxyethoxy)ethoxy)ethoxy) silane, or combinations thereof.

13. A conduit according to claim 6 wherein said silicon compound is a silicate or organoalkoxysilane, said silicate has the formula of Si-(R)₄, each R is independently OCH₃, OCH₂CH₃, (OCH₂CH₂)_mOCH₃, m=1-10, or combinations of two or more thereof; said organoalkoxysilane has the formula of R²_qSi(OR³)_{4-q}, each R² is independently an alkyl group containing about 1 to about 10 carbon atoms; each R³ is independently an alkyl group containing 1 to about 3 carbon atoms; and q=1-3.

14. A conduit according to claim 13 wherein said fluorocarbon silane is perfluoro alkyl ethyl tris(2-(2-methoxyethoxy)ethoxy)silane, perfluoro alkyl ethyl tris(2-(2-methoxyethoxy)ethoxy)ethoxy) silane, or combinations thereof.

15. A conduit according to claim 14 wherein said silicon compound is tetrakis(2-(2-methoxyethoxy)ethoxy)silicate, dimethyldimethoxysilane,

methyltrimethoxy silane, methyltriethoxysilane, 3-aminopropyltriethoxy silane, N-(2-aminoethyl)3-aminopropyldiethoxy silane, 3-glycidoxypropyltrimethoxy silane, one or more partial condensation products thereof, or combinations of two or more thereof.

5 16. A conduit according to claim 15 wherein said surfactant is R_f^1 -
 $CH_2CH_2-O-(CH_2CH_2O)_{11}-H$, $C_9H_{19}-C_6H_4-O-(CH_2CH_2O)_{50}-H$, R_f^1 -
 $CH_2CH_2SCH_2CH(OH)CH_2N(CH_3)_3^+Cl^-$, $C_{12}H_{25}(OCH_2CH_2)_4OSO_3^-NH_4^+$, $C_{12}H_{27}-$
 $C_6H_4-SO_3^-Na^+$, or combinations or two or more thereof wherein R_f^1 is a C_{3-18} perfluoroalkyl group.

10 17. A conduit according to claim 16 wherein said conduit is a ceramic, polyimide, or metal, or is produced from a ceramic, polyimide, or metal.

18. A conduit according to claim 17 wherein said conduit is an ink jet printer nozzle or a nozzle for a machine.

19. A process comprising (1) contacting on the surface of a conduit with a substantially aqueous emulsion comprising, or produced from, a hydrolyzed fluorocarbon silane product, a surfactant, a silicon compound, an acid or base, and water; and (2) drying said emulsion to produce a thin-film having a thickness of from about 0.1 nm to about 10,000 nm on the surface of said conduit wherein said fluorocarbon silane has the formula $R_f-(CH_2)_p-Si\{-(O-CH_2CH_2)_n-OR^1\}_3$; said silicon compound is a silicate or an organoalkoxysilane; R_f is a C_{3-18} perfluoroalkyl group or combinations of two or more thereof; each R^1 is independently one or more C_{1-3} alkyl groups; p is 2 to 4; and n is 2 to 10.

20. A process according to claim 19 wherein said conduit is a nozzle.

21. A process according to claim 20 wherein said emulsion comprises or is produced from said hydrolyzed fluorocarbon silane, said surfactant, said silicon compound, and said catalyst.

22. A process according to claim 21 wherein said fluorocarbon silane is perfluoro alkyl ethyl tris(2-(2-methoxyethoxy)ethoxy)silane, perfluoro alkyl ethyl tris(2-(2-(2-methoxyethoxy)ethoxy)ethoxy) silane, or combinations thereof.

23. A process according to claim 20 wherein said silicon compound is a silicate or organoalkoxysilane, said silicate has the formula of $\text{Si}-(\text{R})_4$, each R is independently OCH_3 , OCH_2CH_3 , $(\text{OCH}_2\text{CH}_2)_m\text{OCH}_3$, $m=1-10$, or combinations of two or more thereof; said organoalkoxysilane has the formula of $\text{R}^2\text{Si}(\text{OR}^3)_{4-q}$,

5 each R^2 is independently an alkyl group containing about 1 to about 10 carbon atoms; each R^3 is independently an alkyl group containing 1 to about 3 carbon atoms; and $q=1-3$.

24. A process according to claim 23 wherein said fluorocarbon silane is perfluoro alkyl ethyl tris(2-(2-methoxyethoxy)ethoxy)silane, perfluoro alkyl ethyl tris(2-(2-methoxyethoxy)ethoxy) silane, or combinations thereof.

25. A process according to claim 24 wherein said silicon compound is tetrakis(2-(2-methoxyethoxy)ethoxy)silicate, dimethyldimethoxysilane, methyltrimethoxy silane, methyltriethoxysilane, 3-aminopropyltriethoxy silane, N-(2-aminoethyl)3-aminopropyldiethoxy silane, 3-glycidoxypropyltrimethoxy silane, one or more partial condensation products thereof, or combinations of two or more thereof.

26. A process according to claim 25 wherein said surfactant is $\text{R}_f^1-\text{CH}_2\text{CH}_2-\text{O}-(\text{CH}_2\text{CH}_2\text{O})_{11}-\text{H}$, $\text{C}_9\text{H}_{19}-\text{C}_6\text{H}_4-\text{O}-(\text{CH}_2\text{CH}_2\text{O})_{50}-\text{H}$, $\text{R}_f^1-\text{CH}_2\text{CH}_2\text{SCH}_2\text{CH}(\text{OH})\text{CH}_2\text{N}(\text{CH}_3)_3^+\text{Cl}^-$, $\text{C}_{12}\text{H}_{25}(\text{OCH}_2\text{CH}_2)_4\text{OSO}_3^-\text{NH}_4^+$, $\text{C}_{12}\text{H}_{27}-\text{C}_6\text{H}_4-\text{SO}_3^-\text{Na}^+$, or combinations or two or more thereof wherein R_f^1 is a C_{3-18} perfluoroalkyl group.

27. A process according to claim 26 wherein said conduit is a ceramic, polyimide, or metal, or is produced from a ceramic, polyimide, or metal.

28. A process according to claim 27 wherein said conduit is an ink jet printer nozzle or a nozzle for a machine.

29. A process according to claim 13 wherein said drying is carried out in a range from $150^\circ\text{C}-500^\circ\text{C}$.